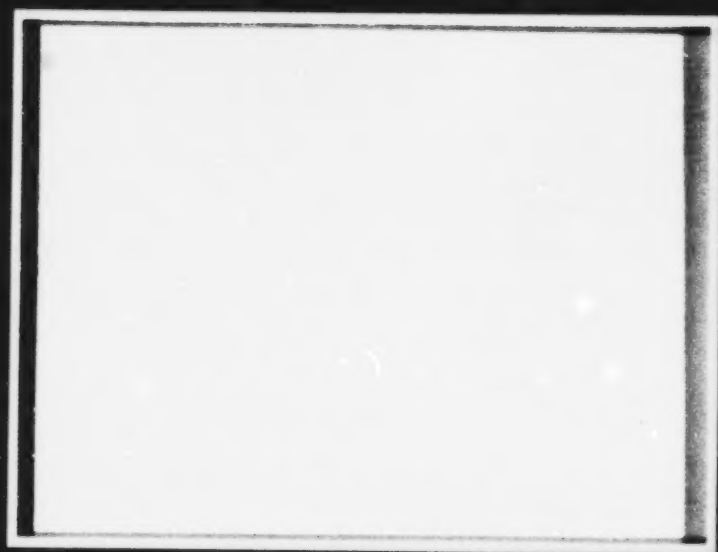




CREDA

Yukon 18

Guild Hall Retrofit

CREDA is a program which has been jointly funded by Energy, Mines and Resources, Canada and the Yukon Government, Department of Economic Development and Tourism. For more information or copies of reports contact the Energy and Mines Branch, Yukon Government, Box 2703, Whitehorse, Y1A 2C6.

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FOREWORD

The availability of secure and affordable energy supplies is a subject of national concern. Our primary energy sources are becoming more costly and less accessible. However, Canada has both the resources and technical expertise needed to develop renewable and alternate sources of energy.

The Governments of Yukon and Canada have entered into a Conservation and Renewable Energy Demonstration Agreement as one means of pursuing this end. Cost shared by the Territorial and Federal governments, CREDA has a budget of \$3.3 million and is dedicated to the development and demonstration of conservation and renewable energy technologies.

The objectives of CREDA are:

- to develop and demonstrate promising new technologies, which when widely adopted, will exploit renewable resources, conserve energy and/or use energy more efficiently,
- to develop broad public awareness of the potential of renewable energy and conservation technology,
- to provide opportunities for the commercial application of the technologies,
- to create economic spin-off benefits for manufacturing, industry and commerce and
- to create employment in new or existing energy-related industries.

The Guild Hall demonstration project which is discussed in this report is an important attempt to broaden public awareness as to how public recreation and community buildings can be made energy efficient and operationally affordable. A large proportion of Yukon's community clubs and organizations are facing rising operational costs beyond their means.

because of high heating fuel bills. This project and others undertaken in different jurisdictions might significantly reduce their energy needs and costs and keep many organizations from closing their community facilities altogether.

EXECUTIVE SUMMARY

The following report demonstrates the economic viability of an exterior rewrap retrofit performed on a public community facility for the performing arts.

The Guild Hall Society operates the "Guild Hall" which originally consisted of two mess halls built by the American army. The interior of the buildings had been renovated to house a 100 seat theatre and an art gallery. It was determined that major capital investment was still required in order to renovate the exteriors and to save energy which would guarantee the continued operation of the facility.

The exterior retrofit consisted of constructing a super-insulated passageway to link the two halls as well as completely wrapping the facility with six millimetre polyethylene to provide an airtight barrier. The roofs and walls were reinsulated and insulation levels were increased to RSI 10.5 in the ceilings and RSI 7.7 in the walls. The installation of a propane fuelled furnace was also included in the retrofit package.

Prior to the renovations and retrofitting, the Guild Hall facility was almost unusable. The demonstration project transformed the cold, drafty buildings into an attractive, comfortable and functional centre for the performing arts. Heating requirements have been reduced to 500 MJ/m² of floor space annually compared to a predicted 1,760 MJ/m² of floor space based on "HOTCAN" analysis of the heating requirements without the energy conservation measures.

Résumé pour l'exécutif

Le rapport suivant démontre la viabilité, du point de vue économique, de la rénovation et re-isolation extérieure d'un édifice public communautaire utilisé pour les spectacles.

Le 'Guild Hall Society' gère et opère l'ensemble des salles de spectacles connu sous le nom de 'Guild Hall' et qui ne consistait à l'origine qu'en deux salles de mess construites par l'armée américaine. L'intérieur des bâtiments avait été rénové de façon à transformer l'un en une galerie d'exposition et l'autre en un théâtre pouvant accommoder 100 spectateurs. Il fut déterminé que de gros capitaux devraient être investis dans le but de rénover l'extérieur des bâtiments et d'économiser l'énergie, ce qui aurait pour effet d'assurer l'utilisation ininterrompue du centre d'arts.

La rénovation extérieure a consisté à construire un corridor super-isolé pour joindre les deux salles et à recouvrir l'ensemble des bâtiments de six millimètres de polyéthylène pour créer une barrière étanche à l'air. On a isolé à nouveau les toits et les murs et les niveaux d'isolation ont été portés à RSI 10.5 dans les plafonds et RSI 7.7 dans les murs. Pour compléter les travaux de rénovation, on a procédé à l'installation d'une fournaise au gaz propane.

Avant que n'ait été complétées les rénovations, tant extérieures qu'intérieures, les salles du 'Guild Hall' étaient à toute fin pratique inutilisables. Ce projet de démonstration a transformé deux bâtiments froids et pleins de courants d'air en un centre attrayant, confortable et fonctionnel qui peut être utilisé aussi bien pour les arts plastiques que pour les spectacles. Les besoins annuels en chauffage ont été réduits à 500 MJ/M^2 de surface de plancher comparativement aux 1760 MJ/M^2 de surface de plancher qui avaient été prévus en se basant sur une analyse 'HOTCAN' des besoins en chauffage ne tenant pas compte des mesures visant à la conservation de l'énergie.

SECTION I: INTRODUCTION

The Guild Hall Society in conjunction with the Canada-Yukon Conservation and Renewable Energy Demonstration Program undertook to demonstrate how, in practical terms, community and recreation buildings can be made energy efficient and affordable to operate by non-profit organizations.

The Society is a registered charitable organization founded in 1980 by a group of Whitehorse citizens for the purpose of providing the community with a small cultural arts centre. The Society operates the "Guild Hall" which consisted of two mess halls originally built by the American army. In 1981, members and volunteers renovated and equipped the halls to use as a 100-seat theatre and an art gallery. Though the buildings had been made attractive and functional inside, major exterior renovations were still required.

The Society decided that they would have to make a major capital investment in order to guarantee the continued operation of the facility. Development would have to accommodate both the need for expansion and energy saving requirements. The society's objectives were stated as follows:

- in order to continue operating as a community resource, we must cut back drastically on energy consumption costs,
- in order to serve the public better, we must provide sheltered entranceways, a passage between the two buildings and lobby space and
- in order to ensure the continued existence of this facility as a community resource, whether it is used by the Guild or any other community group, the buildings must be upgraded.

It was decided that an exterior retrofit should be carried out in conjunction with the construction of a super-insulated passageway. The passageway would not only link the two buildings but it would also provide

the additional space required. The retrofit included re-wrapping the entire building with a six millimetre (mm) polyethylene air-vapour barrier and substantially increasing the insulation levels in the walls and ceiling. As well, a propane fueled furnace was installed to replace the antiquated, oil-fired furnaces located in the crawlspace of each building.

The needs of the Society to upgrade their facility and, at the same time, lower their operating costs are not uncommon. Many Yukon community clubs and organizations, local governments and Indian Bands are facing similar problems. To help these organizations, the demonstration project serves two basic functions.

Firstly, prior to the Guild Hall demonstration project, exterior retrofits of this nature had not been undertaken, neither by the residential nor commercial sectors, in Yukon. Because of the retrofit, the Society achieved significant reductions in their energy (heating) requirements. This indicates that the exterior retrofit has potential for use in Yukon, particularly, by those organizations experiencing severe financial strain from ever increasing fuel bills required to operate their community facilities. If heating requirements can be reduced by 90 percent or even less, then these facilities have a better chance to remain functional. Specific examples of similar facilities in the Yukon which would benefit from a building rewrap include the Takhini Recreation Centre, the Dawson City Community Hall and the Watson Lake Community Centre.

Secondly, the demonstration project provides an opportunity to transfer technical information regarding exterior retrofits to community organizations, local governments and Band Councils. Through information displays, techniques workshops and this publication, the information gained from the project shows others how to make their community facilities more efficient, more comfortable and cheaper to operate.

Installing a propane fired furnace instead of a conventional oil furnace had a specific objective: to enhance the public acceptability of propane or natural gas heating appliances if either fuel becomes available in the

Yukon on a larger, more marketable scale. This could occur from the Alaska pipeline or as a direct replacement of oil. One of the main benefits of using propane or natural gas is that high efficiency furnaces have been developed which require 35 percent less fuel than the traditional oil furnace to produce the same heating equivalence.

In 1983, the Yukon Government commissioned a study, Yukon Energy Inventory and Utilization Review, which assesses the applicability of different energy sources available in the Yukon. Marvin Shaffer & Associates Ltd. found that natural gas compared to other energy sources presently used in Yukon to heat residential and commercial buildings has an average levelized cost of \$7.80 versus wood costing \$11.20, heating oil costing \$19.00 and electricity costing \$19.50. More importantly, conservation measures were found to have the lowest cost source. Thus, measures to reduce energy demand are equally, if not more, economical than savings from changing the actual source of energy supply. Marvin Shaffer & Associates Ltd. concluded in their study that conservation should continue to be emphasized by the Yukon Government in energy policy and programs.

However, it may not be easy for an organization to determine the conservation measures which will yield the greatest energy savings for their dollar investment. The dollar returns depend upon such factors as the condition of the existing structure, the measures selected to save energy and money, the acceptable payback period and the ability to upfront the necessary capital costs. Often, if grants or low-interest loans are not available, community organizations are forced to continue with stop-gap measures rather than renovating their facility properly.

The exterior retrofit chosen by the Guild Hall Society is recommended in The Super-Insulated Retrofit Book (Marshall and Argue, 1981) as providing the greatest potential for reducing the fuel requirements of today's buildings.

The installation of a curtain wall, or "re-skinning" an existing house, brings about many advantages. Air changes can be reduced to less than one-tenth of the original rate. Conductive heat loss through the exterior of the house can be reduced to less than 10 per cent of the original factor. Both, in conjunction with

treatment of windows, can reduce total fuel consumption by as much as 95 percent. If properly performed, what was originally a leaky, poorly insulated house with a fuel bill of \$1,000 can be transformed into a comfortable home with a fuel bill of less than \$100.

Beside fuel savings, there are other benefits from this type of retrofit. These include:

- in cases where the building is in need of repair, the incentive to reduce the fuel bill may hasten the decision to upgrade the aesthetics of the building and
- re-insulating the exterior allows for a considerable amount of work to be done without disrupting the interior environment.

A major stumbling block to the widespread application of the exterior retrofit appears to result mainly from people's conventional perception of doing major renovation work only on the interior of buildings. Most importantly, the lack of awareness of the benefits and the ease of the exterior retrofit option has impeded its implementation on the market.

The Government of Yukon, through the Guild Hall demonstration project, hopes to introduce the technology and benefits of the super-insulated exterior retrofit to a broader audience in Yukon, particularly community organizations, local governments and Indian Band Councils.

SECTION II: GUILD HALL PRIOR TO THE RETROFIT

General Description

The Guild Hall facility is located on 14th Avenue in the City of Whitehorse, Yukon. Prior to the exterior renovations, the facility consisted of two identical, rectangular buildings, each 7.6 by 22.9 metres in size. The total floor space was 174 square metres (m²).

The single-storey buildings are situated parallel to one another and separated by approximately nine metres. The wood-frame constructions are without windows or basements; each building had an oil fired, forced air heating system with the furnace and heating distribution ducting located in the crawlspace under each building. The heating systems were unreliable and had to be replaced if energy savings were to be gained. The buildings were cold, drafty and poorly insulated as they had been built during World War II by the American Army for the purpose of mess halls.

In September, 1980, after many years of vacancy, the Porter Creek Citizens Association donated the buildings to the Guild Hall Society. Throughout the following year, crews of volunteers renovated and equipped the interiors. Once the renovations were completed, the total capital expenditure, including the value of the donated buildings, was estimated at \$225,000.

The facility was opened for public use in September, 1981. Since the Society does not receive subsidies, all operational costs are paid by facility rentals. During the first year of operation it became a home base for a number of cultural groups, one of which is a major user, the Guild Productions Society. The public response to their first full season of plays and concerts was excellent. However, despite a successful first year of operation, the Guild Hall Society determined that capital investment was still required, particularly to repair the leaking roofs, to replace the heating appliances and to provide additional space.

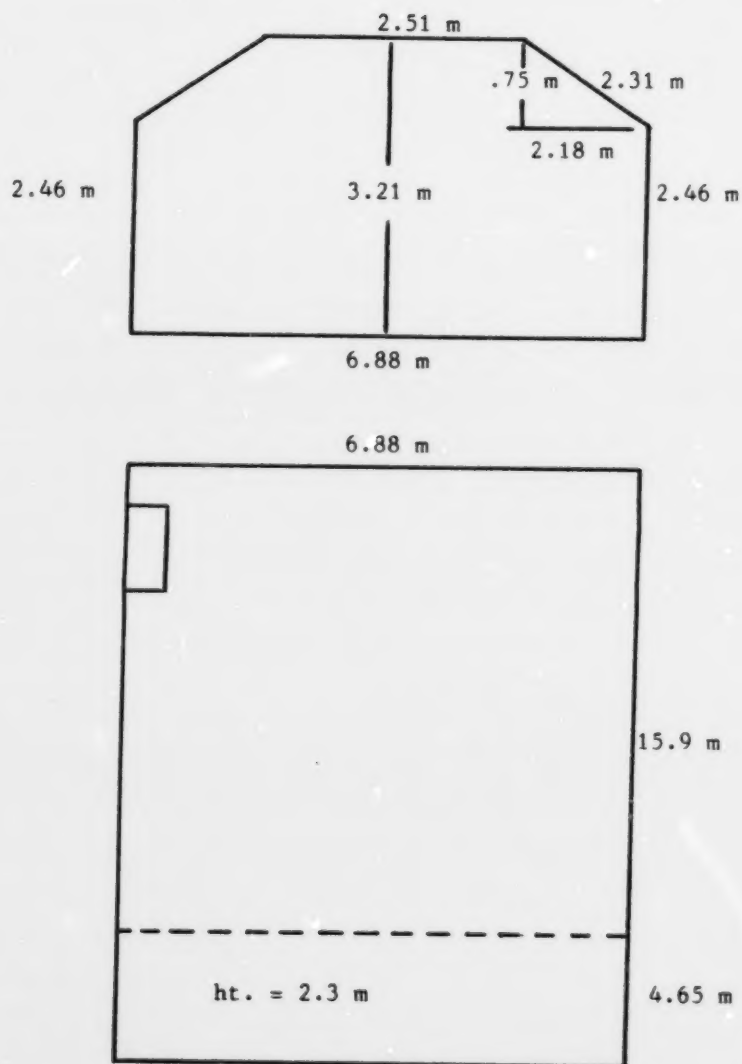
The Society wished to incorporate conservation measures into the construction program which would ensure the energy savings needed to guarantee the continued operation of the Guild Hall. Several factors were assessed by the Society to determine the conservation measures which would provide the best energy savings. Included in the assessment were the results from airtightness testing, measurement of existing insulation in the walls and ceiling and consumption rates of electricity and heating oil. This information is also required to use the computer programs, such as "Ener\$ave" and "HOTCAN" produced by Energy, Mines and Resources Canada to determine energy savings which can be gained from conservation measures. The HOTCAN computer program was used to analyze the conservation needs for the Guild Hall and the results of the analysis are discussed in Section III: Details of Renovations and Retrofit.

Airtightness Testing

Airtightness testing was conducted by a consultant to determine the air changes occurring within an envelope area of 141 m² and 421 cubic metres in volume. (Figure 1 shows the dimensions and shape of the envelope area.) Air change refers to the rate at which the total volume of air is exchanged for cold, outdoor air, by leaking in and out of the building--through open doors, around windows, through ceilings and walls, up the chimney and so on.

The first air infiltration test were conducted on August 23, 1982. The conditions and results of the test are outlined in Figures 2 and 3. The test indicated an air change rate of 5.23 air changes per hour (ACPH) at a pressure of 10 pascals (Pa) and 12.09 ACPH at 50 Pa. The air change rate of a traditionally constructed home ranges between four to eight ACPH at 50 Pa of air pressure. The recommended standards provided by the Canadian General Standards Board are 1.5 ACPH at 50 Pa of pressure for a normal conservator (R-2000) home and two to 2.5 ACPH at 50 Pa of pressure for energy efficient housing. Comparing the Guild Hall rate of air change to these standards confirms the leaky construction that was evident around the facility during the test.

FIGURE 1
AIRTIGHTNESS TESTING AREA



Envelope Area: 141 m²

Volume: 421 m³

Source: Don Willems, Northern Retrofit

FIGURE 2

AIR TIGHTNESS TEST REPORT

AUGUST 23, 1982

IDENTIFICATION

• DATE August 23, 1982
 • TIME 10:30 AM
 • CLIENT YTG
 • ADDRESS Guild Hall
 • PHONE NO. (RES.) _____ (BUS.) _____
 • TECHNICIAN Don Willems
 • TEST PURPOSE Northern Retrofit
☐ PRE-RETROFIT ☐ POST-RETROFIT
☐ NEW HOUSE TEST ☐ RESEARCH
 • COMMENTS _____

DESCRIPTION

• CONSTRUCTION DATE _____
 • WALL CONSTRUCTION _____
 • NO. OF STORIES _____
 • BASEMENT _____
 • HEATING SYSTEM _____
 • D.H.W. SYSTEM _____
 • SIDING _____
 • WINDOWS _____
 • VENTILATION SYSTEM _____
 • ENVELOPE AREA 141 m²
 • INTERIOR VOLUME (HEATED) 421 m³

TEST CONDITIONS

OUTSIDE

• TEMPERATURE (T_o) 11°C
 • WIND (VEL. AND DIR.) 7 km S.E.
 • RELATIVE HUMIDITY (RH_o) _____
 • AIR PRESSURE _____
 • PRECIPITATION Nil
 • SOLAR RADIATION _____
 • SKY/CLOUD CONDITIONS Clear

INSIDE

• TEMPERATURE (T_i) 14°C
 • RELATIVE HUMIDITY (RH_i) _____
 • AIR PRESSURE _____
 • T_i/T_o DIFFERENCE 3°C

HOUSE CONDITIONS

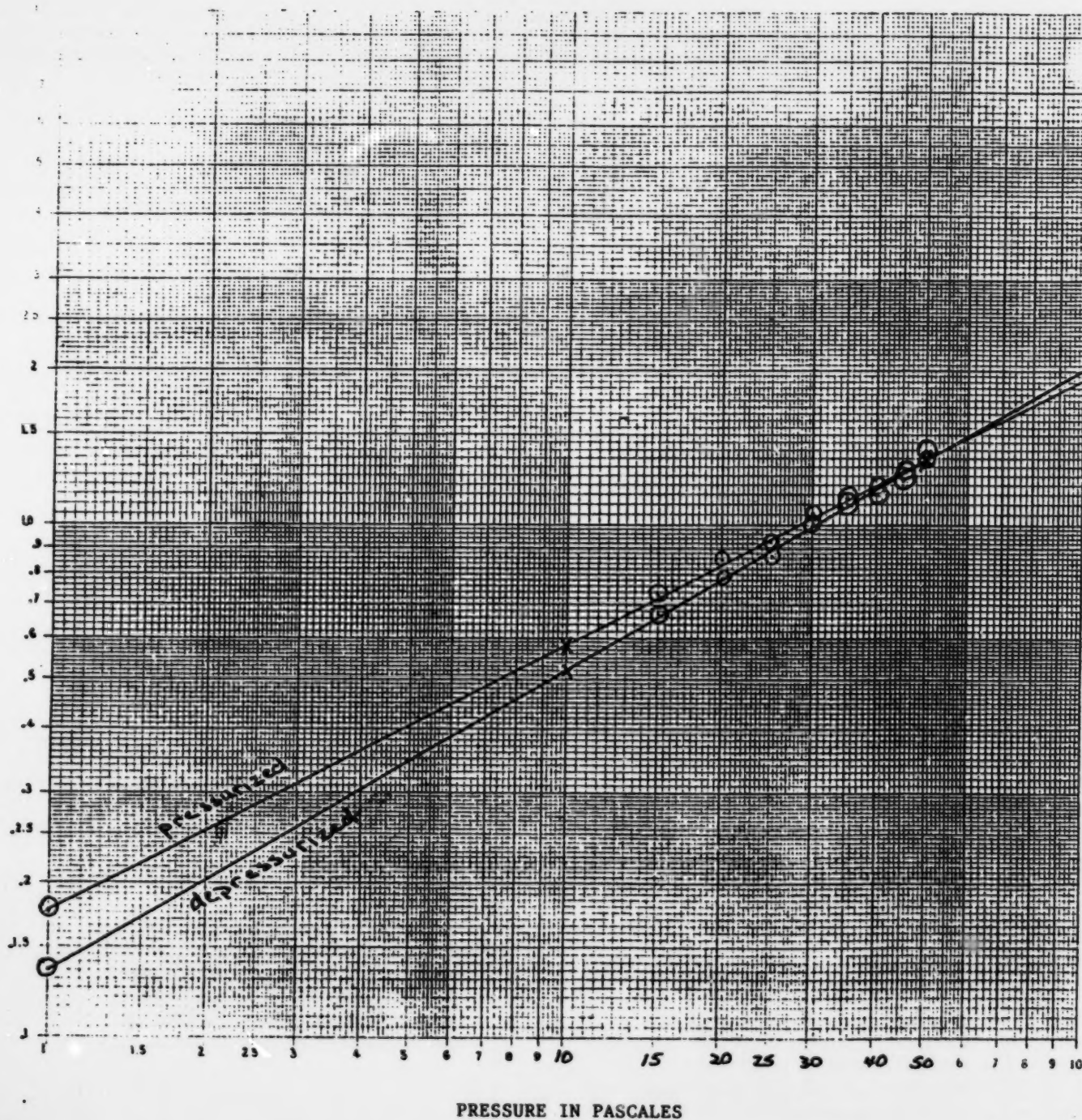
• VENTS: ☐ OPEN ☐ SEALED
 • FIREPLACE: ☐ CLOSED ☐ BLOCKED ☐ SEALED
 • FURNACE: ☒ OPEN ☐ SEALED
 COMMENTS All rents including
heat rents sealed

TEST RESULTS

PRES-SURE (PA)	FLOW (M ³ /S)	
10		PRESSURIZED ☐
15	0.672	DEPRESSURIZED ☒
20	0.788	
25	0.863	
30	1.013	
35	1.107	
40	1.189	EXPONENT (N) <u>0.587</u>
45	1.277	CONSTANT (C) <u>0.135</u>
50	1.334	CORRELATION <u>0.994</u>
55		
60		

AIR FLOW AT 10 PA. 0.52 M³/SEC
 AIR FLOW AT 50 PA. 1.34 M³/SEC
 E.L.A. 0.21 SQ.M. @ 10 PA.
 AIR FLOW/UNIT AREA AT 50 PA. 3.05 L/m²/S
 AIR CHANGES/HR. AT 10 PA. 4.69
 AIR CHANGES/HR. AT 50 PA. 12.09

FIGURE 3
AIRTIGHTNESS TEST PROFILE
AUGUST 23, 1983



Source: Don Willems, Northern Retrofit

Insulation Values

The standard method of classifying the ability of a building to resist the flow of heat through it is by assigning a RSI value to the insulation which indicates the thermal resistance of a component. The larger the RSI value of a building material or component, the greater ability the building has to resist heat flow. Or alternatively, the better the building is at keeping the heat in and the cold out.

From observations of the building materials, Table 1 indicates the insulation values for various components, along with the minimum values recommended for the Yukon by Energy, Mines and Resources Canada. The Guild Hall is insulated to approximately half the recommended minimum values; however, this is not uncommon for buildings constructed in the 1940s.

TABLE 1
INSULATION VALUES
PRIOR TO RETROFIT

Component	Actual Value (RSI)	Recommended Minimum Value* (RSI)	Percent of Change
Ceiling	3.5	7.0	100
Walls	2.1	3.7	76
Floor/Crawlspace (over unheated space)	2.1	4.9	129

*Insulation values recommended by Energy, Mines and Resources Canada in Keeping the Heat In, 1983.

Insulation values recommended by Canada Mortgage and Housing Corporation (Energy Efficient Housing Construction, 1982) for energy efficient housing in Yukon are:

Ceilings	RSI-10.6
Walls	RSI- 6.9
Foundation walls (50 percent or less below grade)	RSI-3.9
Exposed floors/crawlspaces	RSI-4.7
Slabs on grade	RSI-3.9
Basement floors	RSI-1.8

The values for the Guild Hall were approximately one-third of these recommended standards.

Electrical Use

Since the buildings were not in use for many years up to and including the 12 month period of interior renovations carried out by the Society, electrical consumption figures prior to the retrofit are available only for a six-month period. The amount of electricity used at the Guild Hall during this period was largely for lights and sound equipment which was associated with stage use. Table 2 shows the amount of electricity used during the period between September, 1981 through to February, 1982.

TABLE 2
ELECTRICAL CONSUMPTION BEFORE RETROFIT
SEPTEMBER, 1981 TO FEBRUARY, 1982

Month	Main Stage (kWh)	Concert Stage (kWh)	Total (kWh) (GJ)	
September, 1981	679	654	1,333	4.8
October	1,664	1,004	2,668	9.6
November	1,330	910	2,240	8.1
December	2,448	1,505	3,953	14.2
January, 1982	1,807	1,361	3,168	11.4
February	<u>1,065</u>	<u>1,002</u>	<u>2,067</u>	<u>7.4</u>
Six Month Total	8,993	6,436	15,429	55.5
Estimated Annual Total*	16,200	11,600	27,800	100.1

*Estimates provided by the Guild Hall Society.
Source: Electrical bills provided by the Guild Hall Society.

The Society extrapolated these figures for a full year taking into consideration that summer stage use tends to be less than winter stage use. The total annual electrical consumption for both buildings was calculated at 27,800 kilowatt hours (kWh) or 100.1 gigajoules (GJ). Electrical use for the main stage was 16,200 kWh (58.3 GJ) and for the concert stage, it was 11,600 kWh (41.8 GJ). This amounts to an electrical use of 93 kWh (0.3 GJ) per m² of floor space for the main stage area and 66 kWh (0.2 GJ) per m² of floor space for the concert stage area.

Given the nature of the uses of the buildings, the Society did not consider this rate of electrical use excessive and no changes were recommended to the electrical system.

Heating Oil Use

Table 3 shows the heating oil deliveries made to the Guild Hall for the period from March, 1981 to February, 1982. From these figures, it appears that only 11,761 litres or 470 GJ were used for the one-year period. This represents a consumption rate of 1.35 GJ/m² of floor space which appears unrealistically low for such a poorly insulated, drafty facility. It is assumed that the records are incomplete or misleading.

TABLE 3
HEATING OIL CONSUMPTION BEFORE RETROFIT

<u>Delivery Date</u>	<u>Quantity in Litres</u>
March 3, 1981	721
30	432
April 7	435
14	265
28	486
May 5	194
29	236
June 2	246
July 7	166
10	17
September 18	315
October 16	643
November 20	581
December 6	604
January 12, 1982	1,347
20	767
25	498
29	1,399
February 2	1,125
5	362
16	922
Total	11,761

Source: Records of fuel oil deliveries provided by the Guild Hall Society.

Looking at consumption over shorter periods of time, for example three or four month periods, may more accurately represent the actual amount of fuel used. Using the data presented in the Table, fuel used during three specific periods were calculated as shown below:

Period A

March 30 to April 28, 1981
(MJ)

1,186 litres = 47,440 Megajoules

599.1 °Days

= 79.02 MJ/ °Day

= 553 GJ annually

= 1.59 GJ/m² of floor space

Period B

December 6, 1981 to February 16, 1982

6,420 litres = 256,800 MJ

2,933.7 °Days

= 87.53 MJ/ °Day

= 613 GJ annually

= 1.76 GJ/m² of floor space

Period C

January 29 to February 16, 1982

2,409 litres = 96,360 MJ

= 578 °Days

= 166.7 MJ/ °Day

= 1,167 GJ annually

= 3.35 GJ/m² of floor space

The amount of fuel consumed during each of the periods is higher than the total yearly amount indicated by the fuel delivery records. From these figures, it is deducted that periods A and B represent the fuel use when the building is basically unoccupied and would be approximately 1.65 GJ/m² of floor space. Period C would represent fuel consumption during occupation, for example, during the production of a play by the Guild Productions Society and equals 3.35 GJ/m² of floor space.

Total Energy Consumption

Table 4 indicates the estimated total energy consumption for a one-year period prior to the exterior retrofit demonstration project. It is estimated that a total of 983.6 GJ were used; this is assuming six months of occupancy and six month of unoccupancy. The energy consumption equals 2.83 GJ/m² of floor space.

TABLE 4
ANNUAL ENERGY CONSUMPTION BEFORE RETROFIT
MARCH, 1981 TO FEBRUARY, 1982

<u>Energy Type</u>	<u>Quantity in GJ</u>	<u>GJ/m² of Floor space</u>
Electrical	100.1	0.29
Fuel Oil	<u>883.5*</u>	<u>2.54</u>
Total	983.6	2.83

*Calculated using an estimated occupancy rate for six months of the year and an estimated unoccupancy rate for the remaining six months of the year.

For acceptable levels of energy consumption in single-storey commercial buildings under 1,000 m² in size, Alberta Public Works uses the standard of 1.1 GJ/m² of floor space. Therefore, the energy consumption of the Guild Hall facility prior to the exterior retrofit was more than double this acceptable standard. If occupancy was assumed to be greater than six months of the year, energy use would increase dramatically; for example, assuming year-round occupancy would yield a total use of 1,267.1 GJ or 3.64 GJ/m² of floor space.

SECTION III: DETAILS OF RENOVATIONS AND RETROFIT

General Description

The Guild Hall Society completed the exterior renovations and retrofit during the summer of 1982. The time line for the entire project was from May to November and consisted of four phases: conceptual design, detailed design, construction period and interior finish work.

The physical expansion was built to provide a covered passageway between the two buildings as well as to provide additional space for a lobby, ticket booth, office, coat check room, workable mechanical room and small storage space. The additional space consisted of 135 m² in size. Also, the outside space directly in front of the addition and between the existing buildings was landscaped and developed as patios and an outdoor stage area. Figures 4 and 5 show the conceptual design and floor plan for the entire facility.

Specific conservation features were designed as part of the expansion and retrofit. Firstly, the walls were insulated to a level of RSI-7.0 and the ceiling to a level of RSI-10.6. Windows were installed south facing to maximize spring and fall solar penetration and they were also triple-glazed. The doors were upgraded to polyurethane filled metal and new weather stripping was applied to all doors.

The exterior retrofit which was chosen was ideal because the existing buildings had no windows to be framed and each building required re-roofing. The retrofit involved re-wrapping the buildings completely with a six mm polyethylene air-vapour barrier (both walls and roof) and reinsulating the entire building from the outside. The building perimeter is 130 metres and the wrap was estimated to require 24 framing sections averaging five metres in length. The procedure is shown in some detail in Figures 6 and 7.

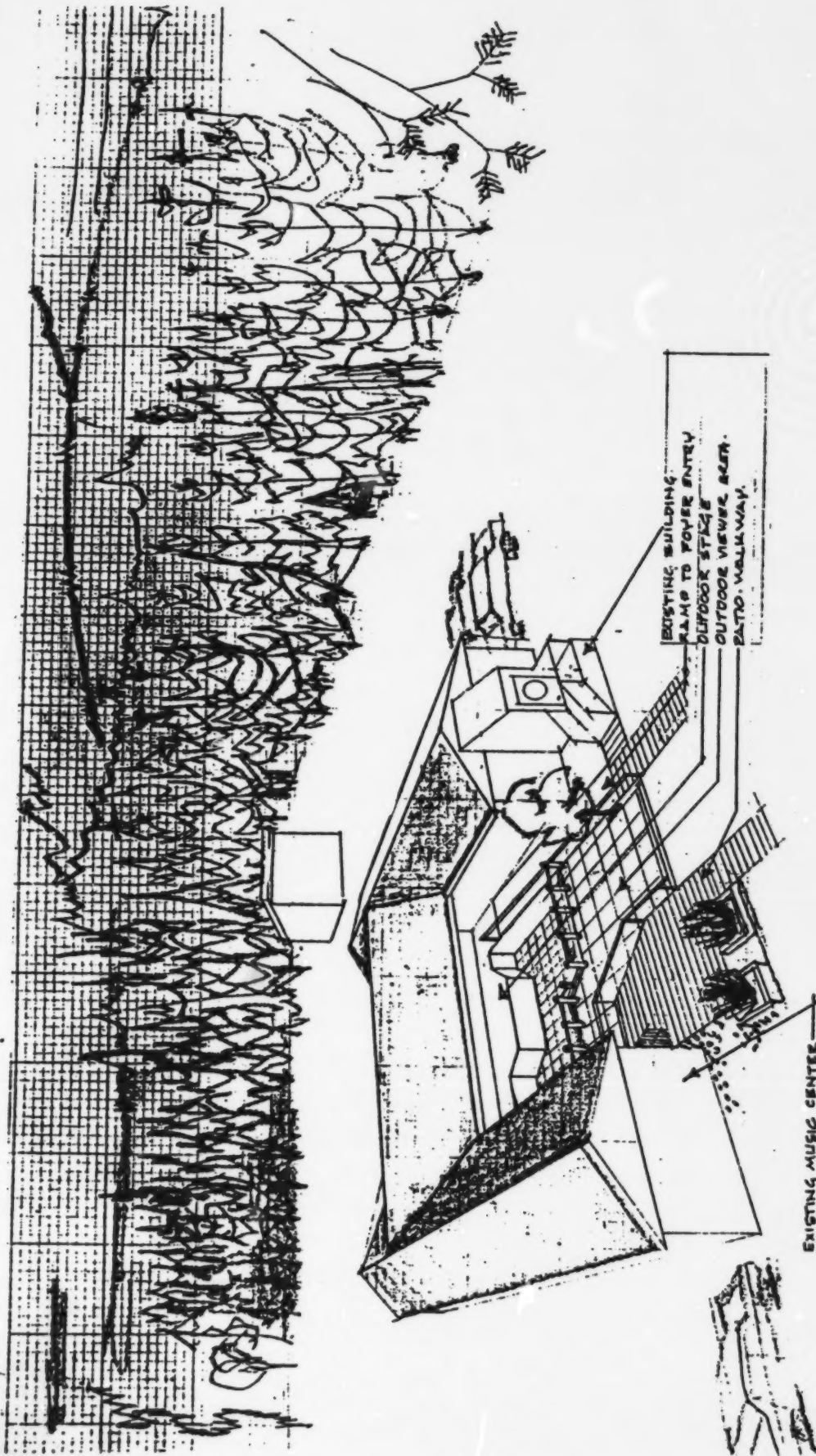


FIGURE 4

GUILD HALL CONCEPTUAL PLAN

GUILD HALL FLOOR PLAN

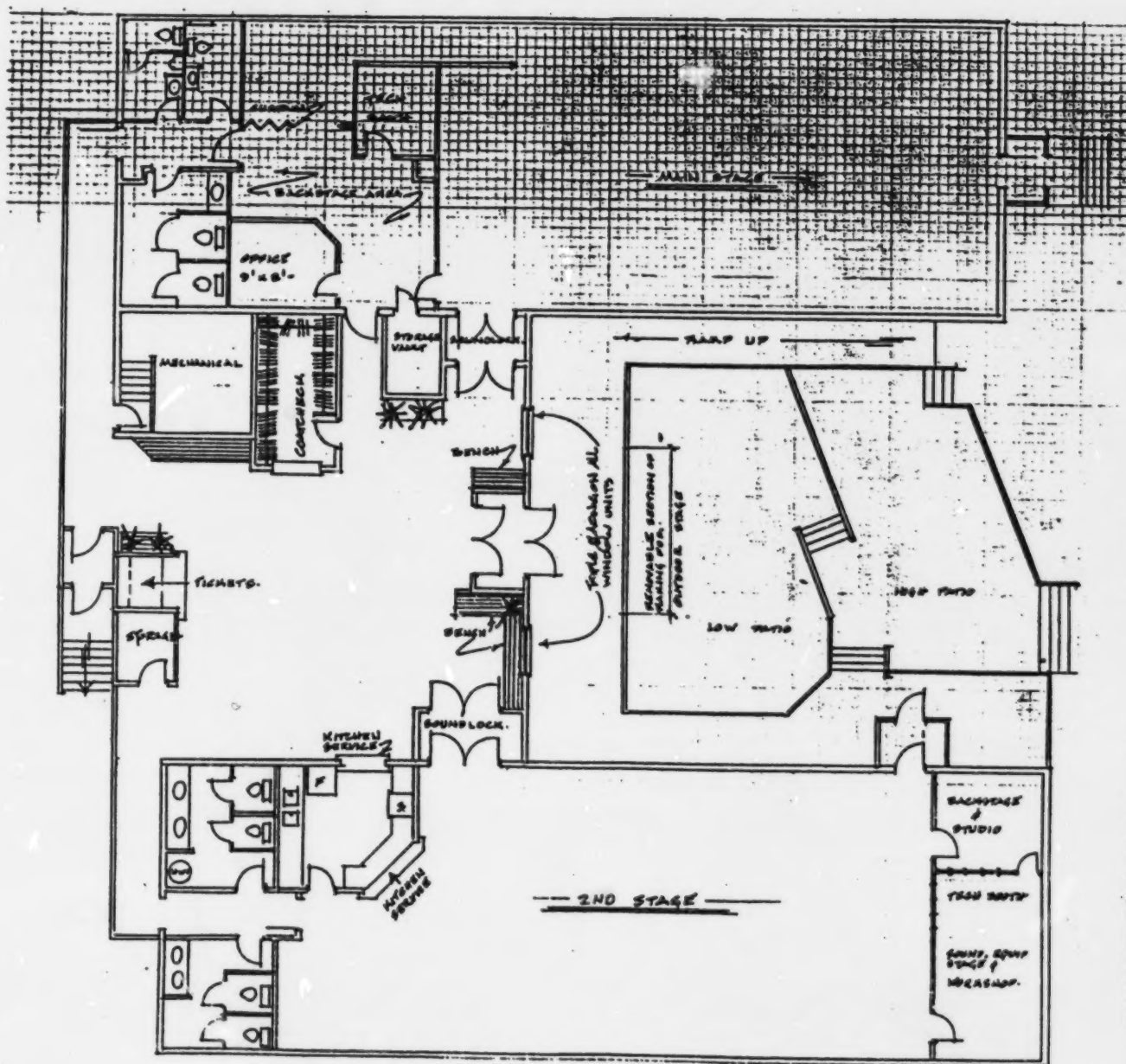


FIGURE 6
REWRAP PROCEDURE

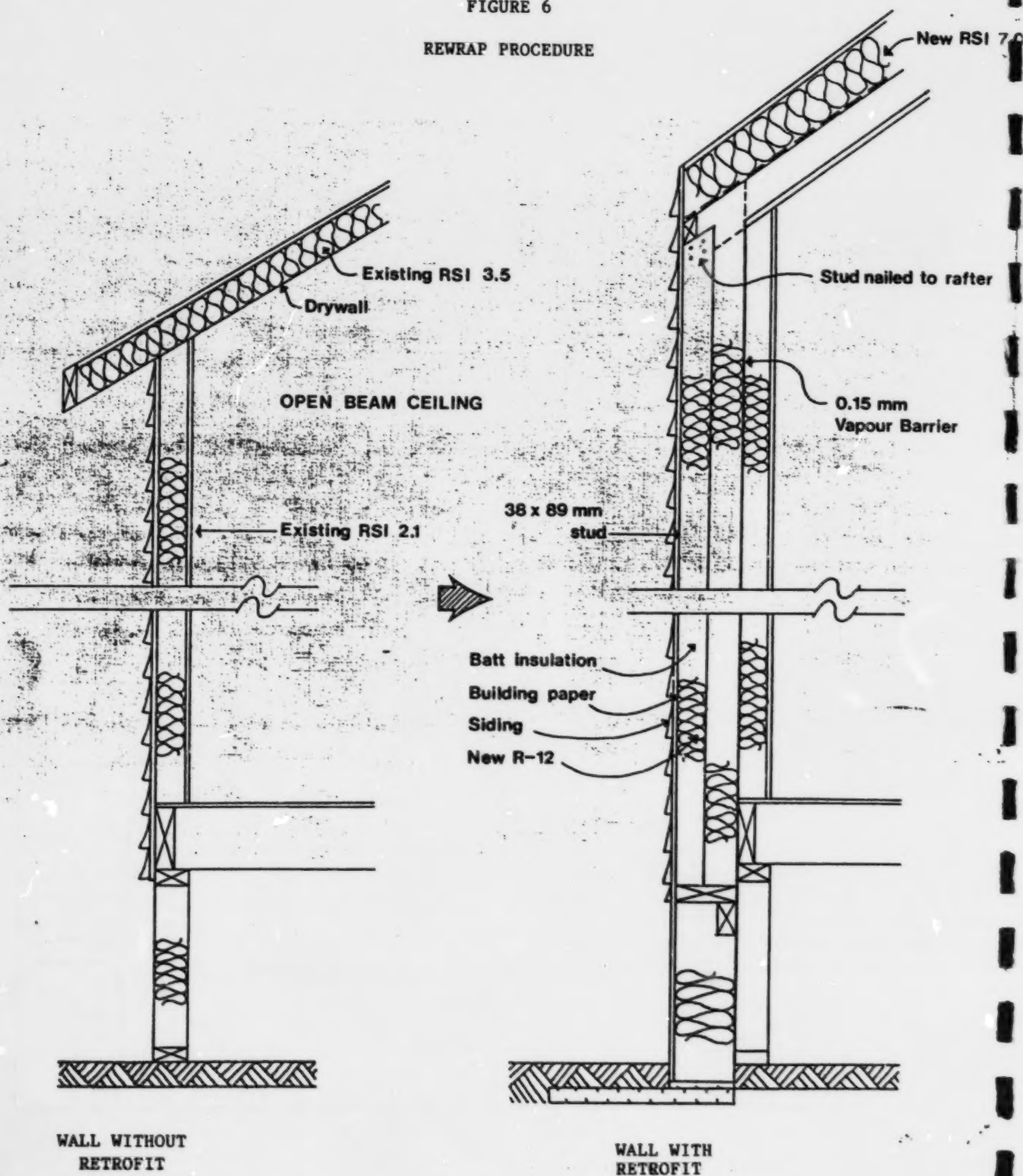
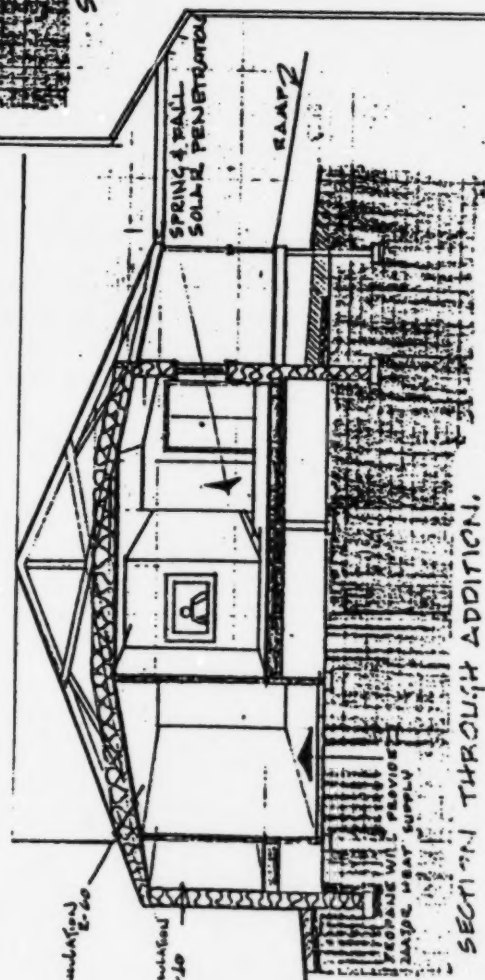
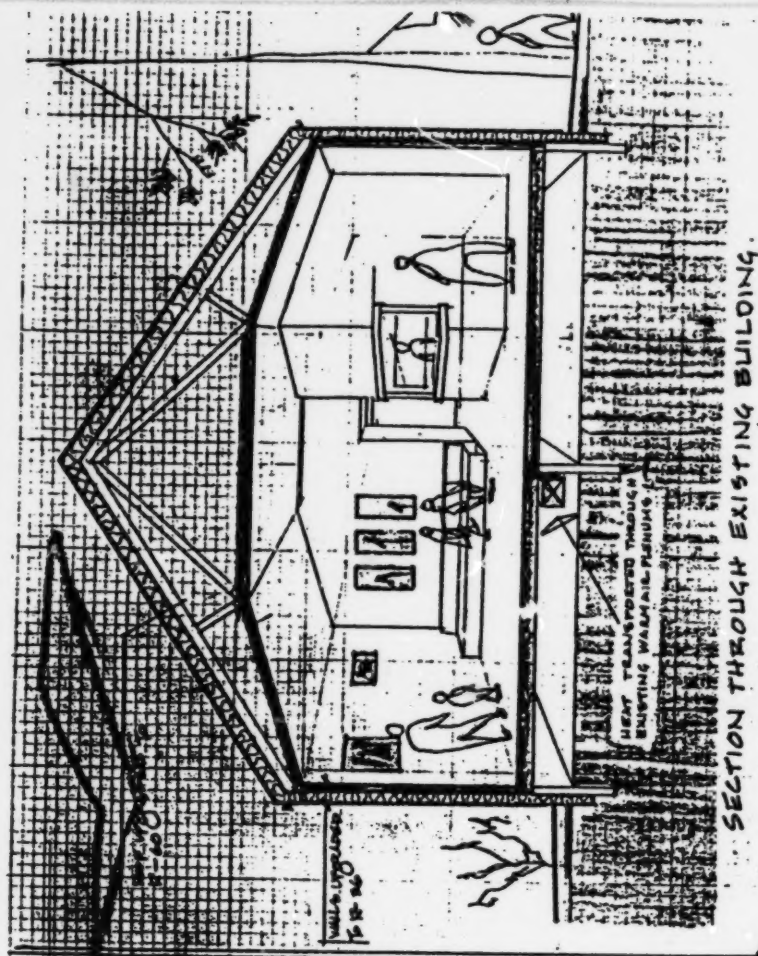


FIGURE 7
CONSTRUCTION DESIGN



- THE UPGRADE WILL CONSIST OF
- WALLS ○ COMPLETELY SURROUNDING EXISTING BUILDINGS WITH HEAVY CONTINUOUS VAPOR BARRIER & SEALING ALL CRACKS & PERFORATIONS WITH ACOUSTICAL SEALANT
 - ② RAISING APPROXIMATELY 2 TIMES THE PRESENT R-VALUE OF INSULATION OUTSIDE THERMAL BARRIER
 - ③ CONTINUING INSULATION TO BELOW GRADE & ALLOWING 3" RIGID INSULATION TO PROTECT FROM HEAT LOSS AT THE FOOTINGS.
 - ROOF ○ SURROUNDING ROOF & GABLES WITH HEAVY CONTINUOUS VAPOR BARRIER.
 - ④ BUILDING UP PRESENT ROOF WITH 2X2 STRAP PERPENDICULAR TO EACH OTHER UNTIL 12" INSULATION & VENTING IS ACHIEVED

The upgrade for the walls included:

- completely surrounding the existing buildings with a heavy, continuous air-vapor barrier and sealing all cuts and perforations with acoustical sealant,
- adding approximately twice the present value of insulation outside that vapour barrier and
- continuing the insulation to below grade and allowing 2.5 centimetre (cm) rigid insulation to protect from heat loss at the footings.

The upgrade for the roof included:

- surrounding the roof and gables with a heavy, continuous air-vapour barrier and
- building up the present roof with 2 x 2 strapping, perpendicular to each other, to achieve 30 cm of insulation and venting space.

The net result was to increase the wall insulation level from RSI-2.1 to RSI-7.7, to increase the roof insulation level from RSI-3.5 to RSI-10.6 and to reduce the air infiltration rate by an estimated 50 percent.

Construction Problems

It is rare that projects are completed exactly as planned. In most cases, problems are encountered which require modifications to the original designs and the Guild Hall demonstration project was no exception. Several of the major problems which were encountered and possible solutions are discussed below for information purposes only.

Due to the location of the footings of the existing Guild Hall structure, the exterior retrofit wall was placed 40 cm from the existing wall for a distance of 75 metres. In order to avoid an air space between the air-vapour barrier and the insulation, it was necessary to add an additional 15 cm (RSI-3.5) of insulation to the RSI-4.9 level which was originally planned.

Bringing the building to the desired level of airtightness was another problem. During a depressurization test of 50 Pa of air pressure, numerous air leaks were observed. Leaks were found around the doors, the light sockets, switches, around the attic hatches, the joist headers in the crawlspaces and around the protrusions in the barrier for the furnace pipes, to name only a few.

Airtightness is crucial in reducing energy bills. Reductions can range up to several hundred dollars annually. As well, airtightness slows the process of structural damage caused by moist indoor air escaping into the outside walls and it increases the length of time it takes the building to freeze up in the event of a power failure or furnace outage.

Condensation was noted at the air-vapour barrier in the crawlspace. Contrary to what was planned, the barrier was installed exactly halfway between two RSI-3.5 batts. There were several possible solutions to overcome this problem: removing the inside batt, removing the inside RSI-3.5 batt and replacing it with a RSI-1.8 batt or installing a new airtight air-vapour barrier on the warm side of all the existing insulation. The Guild Hall Society chose the second option.

Unfortunately, the Society had considerable difficulty with the installation of the propane furnace. Initially, the Society purchased a natural gas appliance which was to be converted by the dealer. However, the Society was later notified that the model was discontinued by the manufacturer; therefore, parts for the conversion were no longer available. There was no alternative but to remove the natural gas furnace and replace it with the proper propane burning appliance.

SECTION IV: PERFORMANCE AFTER RETROFIT

Predicted Energy Savings

The Guild Hall facility was analyzed using a computer program called "HOTCAN" developed by Energy, Mines and Resources Canada. Certain assumptions were made for the analysis and these must be kept in mind when interpreting the results. For example, it was assumed that the Guild Hall's normal occupancy rate is 22 persons during 72 hours per week with the building unoccupied during the night. Other assumptions included a normal space temperature of 20°C, a setback temperature of 10°C and a setback duration of 96 hours per week. If, in fact, these assumptions vary significantly from the actual environment, then the predicted energy savings will be incorrect.

Table 5 outlines the simulation model believed to best represent the Guild Hall building. The model recommended that the roof be insulated to RSI-10.6 and that the walls be insulated between RSI-6.3 to RSI-7.0.

Heat loss calculations on the structure with and without the energy conservation measures provides a heating requirement comparison of 321.1 GJ per year without the measures and 35.0 GJ per year with the measures.

At an oil furnace efficiency of 60 percent and a stove oil price of approximately .40¢ per litre, the reduction in oil costs will be \$5,020 per year. The Society estimated that the building re-wrap and the incremental cost of the energy features on the new passageway will cost approximately \$38,000. Thus the simple payback on the retrofit project is 7.6 years.

Table 6 illustrates the expected savings from the demonstration project. The savings from the retrofit package are shown for a 20-year period although the life of the Guild Hall after renovations is expected to exceed 20 years. Given a 20-year life expectancy, the present value of the savings (discounted at 15 percent) is \$76,950. The PV payback on investment is between eight and nine years.

TABLE 5
GUILD HALL SIMULATION MODEL

Conditions:

Normal Occupancy	22 persons @ 72 hours per week
Night Occupancy	nil
Annual Electrical Consumption	27,429 kWh

	<u>Area (m²)</u>	<u>Insulation (RSI)</u>
Ceiling/Roof	147.2	10.6
Above Grade Walls	104.9 39.2	6.3 7.0
Floor Slab	12.0	1.8
Doors	3.1	1.8
Windows	0.0	--
Total UA Value	= 273.2 BTU/hr/F	
Infiltration	= 200.4 m ² /hr (.17 ACPH)	
Normal Space Thermometer	= 20°C	
Setback Temperature	= 10°C	
Setback Duration	= 96 hrs/week	

TABLE 5 continued..

Heat Requirements in GJ:

<u>Month</u>	<u>Heat Loss</u>	<u>Solar Gain</u>	<u>Internal Gain</u>	<u>Net Heat Required</u>
January	19.1	0.0	11.7	7.4
February	14.3	0.0	10.6	3.8
March	12.9	0.0	11.7	1.2
April	8.3	0.0	11.3	0.0
May	4.5	0.0	11.7	0.0
June	2.0	0.0	11.3	0.0
July	1.7	0.0	11.7	0.0
August	2.0	0.0	11.7	0.0
September	3.9	0.0	11.3	0.0
October	8.0	0.0	11.7	0.0
November	13.0	0.0	11.3	1.7
December	17.3	0.0	11.7	5.6
Annual Totals*	107.3	0.0	138.0	19.6

(870 litres of fuel oil)

*Due to rounding, addition of columns will not equal annual totals.

TABLE 6
ECONOMIC ANALYSIS OF BENEFITS

Year	Energy Conservation Measures			Propane vs Oil Furnace			Present Value at 15% discount
	Oil Savings (\$)	Present Value at 15% (\$)	Cost of Oil	Cost of Propane	Maintenance Savings	Total Savings	
1	5,622	4,889	688	629	165	224	195
2	6,397	4,761	771	692	182	261	197
3	7,053	4,637	863	761	200	302	199
4	7,899	4,516	967	837	220	350	200
5	8,847	4,398	1,083	921	242	404	201
6	9,908	4,283	1,213	1,013	266	466	201
7	11,097	4,172	1,358	1,115	292	535	201
8	12,429	4,063	1,521	1,226	322	617	202
9	13,921	3,957	1,704	1,349	354	709	202
10	15,591	3,854	1,908	1,484	389	813	201
11	17,462	3,753	2,137	1,632	428	933	201
12	19,557	3,655	2,394	1,795	471	1,070	200
13	21,904	3,560	2,681	1,975	518	1,224	199
14	24,533	3,467	3,003	2,172	570	1,401	198
15	27,477	3,377	3,363	2,389	627	1,601	197
16	30,774	3,289				Total	\$2,994
17	34,467	3,203					
18	38,603	3,119					
19	43,235	3,038					
20	48,424	2,959					
		<u>\$76,950</u>					

Notes: Inflation rates: Oil - 12%
Propane - 10%
Efficiencies: Maintenance - 10%
Oil - 60%
Propane - 92%

The Table also illustrates the savings from a high efficiency propane furnace. The direct savings in fuel costs are relatively small because of the low energy requirements of the facility after the conservation measures have been incorporated. However, greater savings are to be realized due to the cleaner burning characteristics of propane, reducing the need for maintenance and lower servicing costs.

Although the exact figures are not available, it is expected that the incremental cost of purchasing and installing a propane furnace versus an oil furnace would be minimal. The propane appliance is more expensive by approximately \$1,500. However, there is no need for a chimney, fuel tank, pump, piping and controls; therefore, the installation charges are significantly less. Furthermore, propane is expected to increase in price at a lower rate than fuel oil indicating that the annual savings shall increase. If natural gas were to become available in Whitehorse, then it is expected that the savings would be even greater at that point.

Financial Costs

The renovations and exterior retrofit completed by the Guild Hall Society was predicted to cost \$125,250. Table 7 shows the estimated labour and material costs for the exterior retrofit only.

TABLE 7
RETROFIT BUDGET AND ACTUAL COSTS

	<u>Budget</u>	<u>Actual</u>
Lumber and building materials	\$24,440	
Insulation	8,550 *(10,050)	29,600
Labour	4,320	19,600
Condensing propane boiler and accessories	5,000	4,800
Contingency	<u>2,690</u>	<u>-</u>
Total	\$46,500	\$54,000

Additional Costs:

Additional insulation material and labour to eliminate space problems by the footings (estimated)	\$ 1,380
Replacement of natural gas furnace (estimated)	\$ 3,000

*Increased to upgrade wall insulation from RS1-2.1 to RS1-10.5.

While the retrofit was estimated to cost \$46,500; the actual costs were \$54,000. This figure may be slightly misleading because of difficulties in accurately separating the retrofit costs from renovations. Assuming that the actual costs indicated on the Table are within the correct ballpark; then the Guild Hall demonstration project cost \$7,500. more than estimated. This does not include the additional costs necessary to rectify the problems encountered during construction and with the furnace.

Electrical Use

Table 8 indicates the electrical use for the Guild Hall facility for approximately 19 months which covers the retrofit period and the first winter season of use following the retrofit. For a one-year period from April 27, 1983 to March 7, 1984, the Guild Hall consumed 24,620 kWh or 88.6 GJ of electricity. Looking at another one-year period following the completion of the retrofit, between October 27, 1983 and November 7, 1984, the electrical consumption was 37,600 kWh or 135.3 GJ. Although the total amount of electricity consumed increased, the electrical consumption per m² of floor space remained the same. The previous rate was 0.29 GJ/m² compared to 0.30 GJ/m².

TABLE 8

ELECTRICAL CONSUMPTION AFTER RETROFIT

<u>Billing Period</u>	<u>Number of Days</u>	<u>Quantity in Kilowatt Hours</u>
March 25 - April 27, 1983	33	2,200
April 27 - May 27	30	1,540
May 27 - June 27	30	580
June 27 - July 27	30	960
July 27 - August 26	30	1,420
August 26 - September 26	31	3,480
September 26 - October 27	31	2,860
October 27 - November 28	32	3,160
November 28 - December 28	30	2,220
December 28 - January 26, 1984	29	3,760
January 26 - March 7	41	4,640
March 7 - April 5	29	3,020
April 5 - May 8	33	2,960
May 8 - June 7	30	2,320
June 7 - July 9	32	2,240
July 9 - August 8	30	3,000
August 8 - September 7	30	2,640
September 7 - October 9	32	3,760
October 9 - November 7	29	3,880

Source: Electrical consumption figures provided by the Guild Hall Society.

Propane Use

Table 9 outlines the propane deliveries made during a one-year period following the retrofit. Between October 16, 1983 and October 19, 1984, the Guild Hall used 8,482 litres of propane which equals a total of 212.1 GJ for the year. This is equal to 0.44 GJ/m² of floorspace and indicates a reduction of 2.4 GJ/m² of floorspace when compared to the estimated annual use of heating oil before the retrofit.

TABLE 9

PROPANE CONSUMPTION AFTER RETROFIT

<u>Billing Date</u>	<u>Quantity in Litres</u>
October 16, 1983	3,200
November 28	1,712
December 20	1,358
January 17, 1984	1,281
April 3	2,306
October 19	1,825

Source: Records of propane deliveries provided by the Guild Hall Society.

Total Energy Consumption

The total energy consumed for a one-year period following the retrofit is outlined in Table 10. The Guild Hall used 357.7 GJ of energy for a one-year period between October, 1983 to November, 1984. This equals 0.74 GJ/m² of floorspace and is considerably lower than the 2.83 GJ/m² of floorspace used during the period between March, 1981 to February, 1982.

TABLE 10

ANNUAL ENERGY CONSUMPTION AFTER RETROFIT

OCTOBER, 1983 TO NOVEMBER, 1984

<u>Energy Type</u>	<u>Total GJ</u>	<u>GJ/m² of Floor Space</u>
Electricity	145.	0.30
Fuel Oil	<u>212.1</u>	<u>0.44</u>
Total	357.7	0.74

Economic Analysis

'Before' and 'after' retrofit comparisons of the energy consumption rates may not be the most accurate means to assess the energy efficiency savings of the demonstration project. For example, a comparison of fuel records can be misleading unless the use and occupancy rates remain relatively stable during two equivalent comparable time periods. This was certainly not the case for the Guild Hall; the building was almost unusable prior to the interior renovations and public use has increased considerably during and following completion of the exterior retrofit. Unfortunately, a daily log of the Guild Hall's occupancy and use was not maintained which would have allowed correlations to be made with the energy use.

The HOTCAN computer analysis determined that the heating requirements without the energy efficiency measures would have been, with current use patterns, in the order of 1,760 MJ/m² of floor space. The Guild Hall is currently using 440 MJ/m² of floor space which definitely is a significant savings.

Energy Savings:	1,320 MJ/m ² of floor space
Annual fuel savings:	25,502 litres of propane
Annual dollar (1984) savings:	\$9,257.23
Cost of retrofit:	\$54,000.00
Simple Payback:	5.8 years

Airtightness Testing

Upon completion of the exterior retrofit, airtightness testing was once again completed by the consultant. Figures 8 and 9 compare the 'before' and 'after' test results. The retrofit results indicate that a 16.8 percent reduction was achieved which is considerably below the hoped for gain of 50 percent.

AIR LEAKAGE TEST REPORT

February 16, 1984

IDENTIFICATION

- CLIENT YTG
- ADDRESS Guild Hall
- PHONE (H) _____ (W) _____
- TECHNICIAN Don Willems
Noethern Retrofit

BUILDING DESCRIPTION

- APPROX. CONSTRUCTION DATE: _____
- BASEMENT? ☐ YES ☐ NO ☐ PARTIAL
- VENTILATION SYSTEM ☐ NONE
- INTERIOR HEATED VOLUME 1,860 m³
- HOUSE STYLE ☐ 1 STOREY ☐ 1 1/2 ☐ 2
☐ 2 1/2 ☐ 3 ☐ SPLIT-LEVEL ☐ BI-LEVEL

BEFORE

PRE-RETROFIT TEST

- ☐ NEW HOUSE ☐ RESEARCH
- DATE _____ TIME _____ AM PM
- TEMPERATURE: IN _____ °C OUT _____ °C
- WIND (VEL. AND DIR.) _____
- AIR PRESSURE _____ Kpa

PRESSURE (PA) FLOW (l/s)

60	_____	_____	
55	_____	_____	
50	_____	_____	
45	<u>184</u>	<u>2,297</u>	$N = 0.639$
40	<u>164</u>	<u>2,082</u>	$C = 200.7$
35	<u>157</u>	<u>1,961</u>	$COR = 0.9977$
30	<u>143</u>	<u>1,804</u>	
25	<u>123</u>	<u>1,519</u>	$ELA \frac{M}{SQ. FT.} 0.350$
20	<u>113</u>	<u>1,398</u>	
15	<u>94</u>	<u>1,155</u>	$AIR CHANGES/HR$
10	<u>72</u>	<u>859</u>	$@ 50 pa: 4.74$

AFTER

POST-RETROFIT TEST

- ☐ NEW HOUSE ☐ RESEARCH
- DATE _____ TIME _____ AM PM
- TEMPERATURE: IN _____ °C OUT _____ °C
- WIND (VEL. AND DIR.) _____
- AIR PRESSURE _____ Kpa

PRESSURE (PA) FLOW (l/s)

60	_____	_____	
55	_____	_____	
50	_____	_____	
45	_____	_____	$N = 0.714$
40	<u>150</u>	<u>1,845</u>	$C = 140.2$
35	_____	_____	$COR = 0.9928$
30	<u>135</u>	<u>1,694</u>	
25	_____	_____	$ELA \frac{M}{SQ. FT.} 0.291$
20	<u>101</u>	<u>1,212</u>	
15	_____	_____	$AIR CHANGES/HR$
10	<u>63</u>	<u>711</u>	$@ 50 pa: 4.4$

HOUSE CONDITION

- VENTS ☐ OPEN ☐ SEALED
- FIREPLACE ☐ CLOSED
☐ BLOCKED ☐ SEALED
- FURNACE ☐ OPEN ☐ SEALED

RETROFIT RESULTS

EQUIVALENT LEAKAGE AREA (ELA)

BEFORE 0.350 AFTER 0.29116.8 % REDUCTION ACHIEVED

COMMENTS:

Source: Don Willems, Northern Retrofit

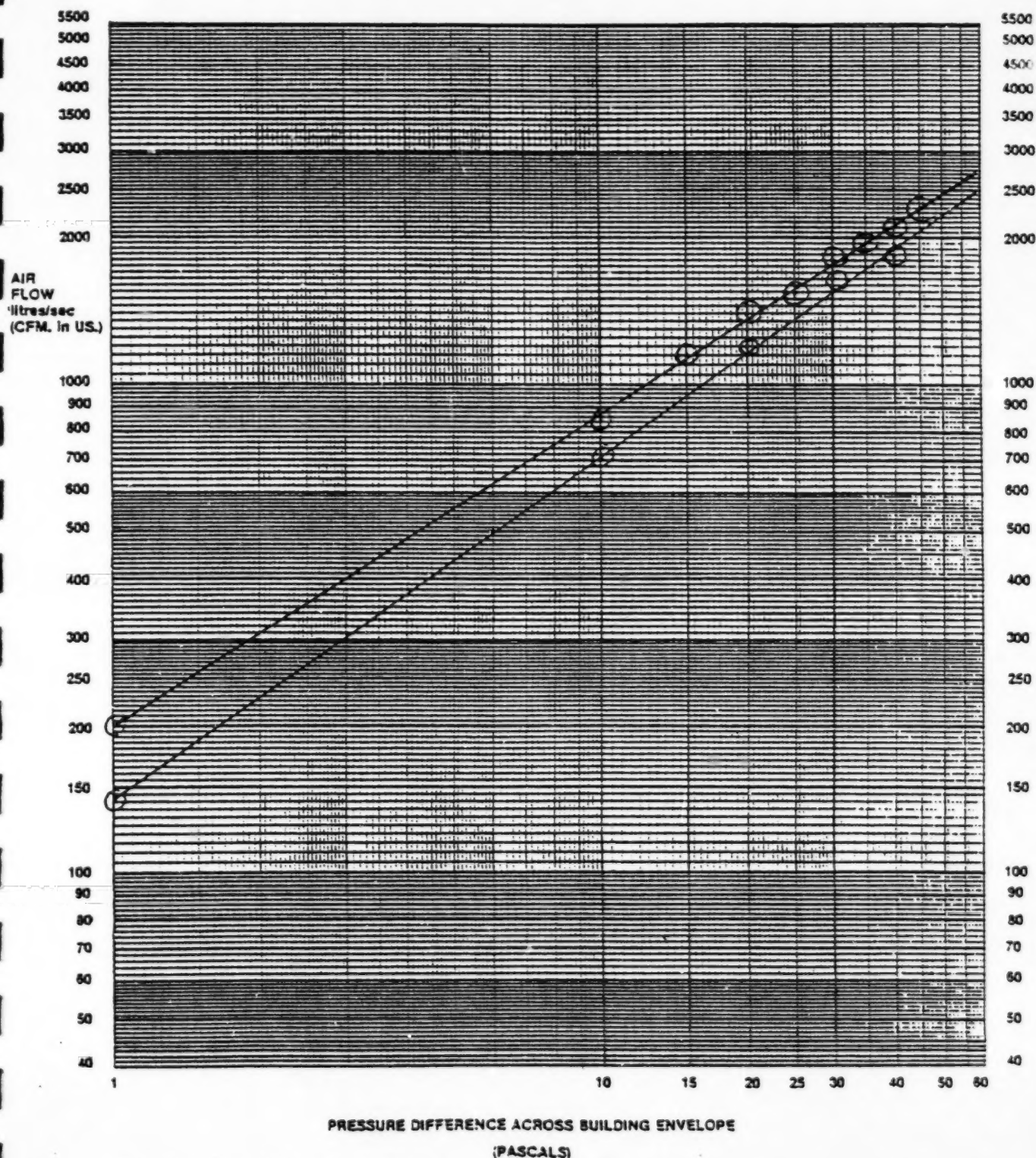
AIR LEAKAGE PROFILE

FIGURE 9

February 16, 1984

Address

Guild Hall



Source: Don Willems, Northern Retrofit 41

Impacts

The energy and economic impacts of the demonstration project are significant. In the case of energy, the conservation measures and exterior retrofit resulted in major fuel and dollar savings. The reduction in annual heating requirements not only saves money for the Guild Hall Society but also reduces the total amount of Yukon's energy resources consumed. Albeit, one demonstration project will not dramatically change the total amount of fuel consumed in Yukon; however, if a number of Yukon communities follow the Guild Hall lead, the total reduction could be significant for the Territory.

The environmental impacts of the project are minimal, mainly related only to propane as a cleaner burning fuel than heating oil. Indirectly, though, one can say that the energy impacts will reduce the amount of disturbance to the natural environment since total energy consumption is reduced.

The social impacts are significant in terms of providing Yukon community clubs and organizations with an alternative to high and rising operational costs for their facilities. The project provided an opportunity to demonstrate conservation measures which can provide a relatively short capital output payback period for major energy savings. Conservation techniques such as those demonstrated may, in fact, allow some organizations to continue to operate facilities which would otherwise need to be closed.

SECTION V: OBSERVATIONS AND RECOMMENDATIONS

For the Guild Hall Society, the dollars saved for heating because of the exterior retrofit are the most important benefit from the project. More importantly, however, the demonstration project shows other Yukon community organizations how they can make their facilities more energy-efficient, more comfortable and less expensive to operate.

Overall, the demonstration project was successful both from the perspective of the Guild Hall Society and the CREDA program. The retrofit (and addition) make the building cheaper to operate and more comfortable to use during the winter months--the time of greatest public use. The project also serves as a visible demonstration of conservation measures appropriate for use in the many Yukon community halls, Indian Band offices, municipal offices, school gymnasiums, curling and hockey rinks, and other numerous facilities which do not meet current standards and which are becoming or have become too costly to operate.

In terms of offering recommendations for future projects of this nature, it is suggested that one area which can be improved is regarding the responsibility and methodology for monitoring and evaluating the project on an ongoing basis during the implementation of the project and upon completion. In order to determine in a useful manner the energy efficiency and savings gained from the conservation technology, it is important that accurate records be kept and tests be undertaken at various pre-determined stages of implementation. In some cases, accurate monitoring may require the installation of equipment. It would be useful to develop a comprehensive monitoring plan prior to commencement of the project and to provide necessary equipment and training to ensure adequate data is collected.

With energy prices constantly on the rise, more community organizations must look to energy conservation technology to save money from lower heating fuel bills. For interested organizations, the first question that must be asked is "How much money can be saved?" The answer to this question will vary greatly depending on the current state of the facility's

insulation, its general condition, type of construction, the local climate and how much investment the organization can make. These and other variables should be taken into consideration to determine the potential savings which can be gained prior to commencing work on conservation programs which may yield disappointing savings. One way to determine precise savings is to keep accurate records of fuel consumption before and after the conservation measures are installed.

The Federal Government has developed computer programs to assist in pinpointing areas where insulation can be economically increased and where other fuel saving measures such as weather stripping, installing storm windows, turning down the thermostat or servicing the furnace are advisable. For each recommendation, the computer analysis will estimate the annual fuel savings and the costs for materials and installation services. It will also estimate the payback period - that is the number of years for the investment to be returned in fuel savings.

The type of upgrading program which best serves the needs of an organization and its cost will vary from facility to facility and from region to region. As a result, it is difficult to provide accurate cost figures that will be widely applicable. The results of the Guild Hall demonstration project may be of assistance; however, each organization should work out their energy conservation requirements to meet their specific circumstances. It is suggested that organizations interested in lowering their heating costs and renovating their facilities consult with the applicable Federal and Territorial government departments for information and assistance.

APPENDIX A

CONVERSION AND ENERGY CONTENT FACTOR

1. Energy Conversion Factors

1 GJ = 277.8 kWh

1 GJ = 947,800 BTU

2. Energy Content Factors

Wood	7.1 GJ/m ³ (of solid wood)
Natural Gas	.031 GJ/m ³
Crude Oil	40 GJ/m ³
Propane	.25 GJ/litre
Heating Oil	.040 GJ/litre
Gasoline	.35 GJ/litre
Diesel	.39 GJ/litre
Coal	5-10 GJ/tonne
Peat	17 GJ/tonne
Municipal Waste	11 GJ/tonne
Hydrogen	151 GJ/tonne

GLOSSARY OF TERMS

- Joule (J): the work done when the point of application of a force of one newton is displaced a distance of one metre in the direction of the force. All forms of energy or work are expressed in joules.
- Megajoule (MJ): multiple of the joule and used to express electrical energy.
- Gigajoule (GJ): multiple of the joule and used to express all energy forms.
- Watt (W): the sole and common unit of power for mechanical, chemical, hydraulic, electrical, thermodynamic, etc. purposes.
- Kilowatt (KW): multiple of the watt.
- Pascal (Pa): the pressure (or stress) which is produced when a force of one newton is applied to an area of one square metre.
- RSI value: indicates the thermal resistance of a component in metric terms. $RSI-1 = R-5.679$ (Imperial measure).



Energy, Mines and
Resources Canada

Énergie, Mines et
Ressources Canada



GUILD HALL RETROFIT

Final Project Summary

Canada/Yukon Conservation and Renewable Energy Demonstration Program

Project No.

3766-4-22

Date:

August, 1984

Sectors:

Institutional/
Commercial

Project Locations:

Whitehorse

Technology:

Conservation

Project Manager:

Robert E. Collins

Status:

Complete

Jurisdiction:

Yukon

Purpose:

To retrofit a public recreational facility for the performing arts.

Description:

Two WWII army mess halls were wrapped completely with 6 mil poly, and reinsulated to RSI 10.5 and 7.7 in the ceiling and walls respectively. A superinsulated passageway was constructed to link the two halls.

Contributors:

Canada/Yukon	\$ 41,000
Guild Society	<u>85,250</u>
	\$126,250

Demonstrated Benefits:

A cold, drafty, virtually unusable building with high operating costs has been transformed into an attractive, comfortable and functional centre for the performing arts. Heating requirements have been reduced to 500 MJ/m² per annum. Without the energy conserving features the fuel bills would have been in the order of \$12,000, or three and one half the current figure.

Further Information:

Robert E. Collins, Program Manager
Energy Branch
Department of Economic Development
and Tourism
Government of Yukon
P.O. Box 2703, Whitehorse, Y1A 2C6
(403) 667-5471

Economic Analysis:

Prior to the retrofit and renovation of the Guild Hall, the building was almost unusable. A comparison of fuel records is therefore meaningless since the Guild Hall was seldom used. However, HotCan analysis has determined that heating requirements without the energy efficient measures would have been, with current use patterns, in the order of 1760 MJ/m^2 . The Guild Hall is currently using 500 MJ/m^2 .

Energy savings:	1260 MJ/m^2
Annual fuel savings:	20,250 litres
Annual Savings:	\$8,150
Cost of retrofit:	\$38,500
Simple payback:	4.7 years

Technical Details:

Results of air-infiltration tests: 0.291 air changes per hour. Overheating of the building has been a problem during performances. This appears to be the result of the superinsulated qualities of the building and also of the location of the thermostat. The original design called for setback thermostats. These were not installed. Instead one thermostat controlling the entire building was placed near the back door. During performances the main part of the building becomes overheated and the staff open the back door for cooling purposes. The sensors in the thermostat detect a cooling in the immediate location of the back door and turn on the heat, exacerbating the problems within the theatre. Installation of a zoned heating system with setback thermostats could solve this problem and reduce the fuel needs by up to 30 per cent.

Information Transfer:

A final report will be produced detailing the conservation measures taken in the retrofit.

- Expansion, Guild Hall,
Performing Arts Center -

